ABUNDANCE AND DISTRIBUTION OF MUSKOXEN AND CARIBOU ON BANKS ISLAND, JULY 1985

Northwest Territories Renewable Resource

ABUNDANCE AND DISTRIBUTION OF MUSKOXEN AND CARIBOU ON BANKS ISLAND, JULY 1985

B. MCLEAN
K. JINGFORS
R. CASE

DEPARTMENT OF RENEWABLE RESOURCES
GOVERNMENT OF THE NORTHWEST TERRITORIES
INUVIK, N.W.T.
1986

File Report No. 64

ABSTRACT

A stratified strip transect survey of Banks Island, NWT was flown between 6 and 14 July, 1985. The survey documented distribution and abundance of muskoxen (Ovibos moschatus) and Peary caribou (Rangifer tarandus pearyi). The total number of non-calf muskoxen observed on-transect was 5867 and the resulting estimate was 25,700 ± 2050 (S.E.) muskoxen. Densities ranged from .21 muskoxen/km^2 on south-central Banks Island to 1.52 muskoxen/km^2 in the Thomsen River area. Mean herd size including calves was 9.5 ± 7.0 (S.D.), and was significantly larger in the Thomsen River area (10.0 ± 7.2 (S.D.)) than in the south-central area (8.6 ± 6.6 (S.D.)), $.05>P>.01$. The proportion of calves counted during the survey (where exact number was known), was 11.8% overall (705/5975) and the proportion of lone bulls was 4.0% (262/6569) of all muskoxen observed. Low-level classification counts after the aerial survey resulted in higher estimates of calf production (16.8%, 357/2129). The total number of non-calf caribou observed on-transect was 843 resulting in an estimate of 5,000 ± 910 (S.E.). Densities ranged from 0.04 caribou/km^2 on southern and eastern Banks Island to 0.63 caribou/km^2 on northwestern Banks Island. Mean group size, including calves, was significantly ($P<.05$) larger in the northwest area, 8.3 ± 8.2 (S.D.) vs 5.5 ± 4.5 (S.D.). The proportion of calves to total classified was 15.3% (137/898).

TABLE OF CONTENTS

ABSTRACT iii

LIST OF FIGURES vii

LIST OF TABLES ix

INTRODUCTION 1

METHODS 3

RESULTS 6
Muskox 6
Caribou 11
Wolves 15

DISCUSSION 16
Survey conditions and design 16
Population characteristics 19
Muskox 19
Caribou 26
Management 28

RECOMMENDATIONS 31

ACKNOWLEDGEMENTS 33

PERSONAL COMMUNICATIONS 34

LITERATURE CITED 35

APPENDIX A. Vegetation analysis conducted in the Thomsen River area, Banks Island, July 1985 38

APPENDIX B. Numbers of muskoxen observed on transect on Banks Island, July 1985 41

APPENDIX C. Number of caribou observed on transect on Banks Island, July 1985 44

LIST OF FIGURES

Figure 1. Transect lines and strata boundaries used during the muskox/caribou survey on Banks Island, July 1985..... 4

Figure 2. Population estimates and densities, by stratum, for muskoxen and caribou on Banks Island, July 1985..... 9

Figure 3. Transect lines used in the 1985 survey, in the area not surveyed in the 1982 survey..... 21

103-05876/

LIST OF TABLES

Table 1. Estimated numbers of muskoxen (non-calves), by stratum, on Banks Island, July 1985 7

Table 2. Muskox herd characteristics (including calves), by stratum, on Banks Island, July 1985 10

Table 3. Estimated numbers of caribou (non-calves), by stratum, on Banks Island, July 1985 13

Table 4. Caribou group characteristics (including calves), by stratum, on Banks Island, July 1985 14

Table 5. Summary of muskox survey information from Banks Island and N.W. Victoria Island 20

Table 6. Grazing intensity by muskoxen in the Thomsen River Valley, July 1985 40

INTRODUCTION

Banks Island (70,000 km^2) is one of the largest islands in the Canadian Arctic and is inhabited by both muskoxen and Peary caribou. Historical information on both species extends back to the 19th century (Zoltai et al. 1980, Hone 1934, Will 1984). Muskoxen on the island had recovered from near extinction at the beginning of this century to an estimated population of 19,000 in 1980 (Vincent and Gunn 1981). The 1980 estimate was calculated from a transect survey of southern Banks Island in 1979 and of northern Banks Island in 1980. The first stratified aerial survey of the island, where survey effort was allocated based on muskox density, was flown in July 1982 (Latour 1985). Latour estimated the size of the muskox population at about 9,400 animals, or only half of the previous estimate.

Peary caribou is the preferred species taken for meat by the Inuvialuit of Sachs Harbour (population: 160). Numbers of caribou on Banks Island appeared stable in the 1970s at between 10,000 and 12,000 (Urquhart 1973, Vincent and Gunn 1981). Latour (1985) estimated a population of 7200 caribou in July 1982. Hunters from Sachs Harbour have expressed concerns over the apparently increasing numbers of muskoxen and the possibility of declining caribou numbers as a result of interspecific competition for food. Wilkinson et al.'s (1976) study of food habits and habitat use did not demonstrate that competition between muskoxen and caribou occurred on Banks Island in the early 1970s.

As part of the Northern Oil and Gas Action Program (NOGAP), a stratified strip transect survey was conducted in July 1985 to estimate current population size and to describe distribution and productivity of both muskoxen and caribou on Banks Island. In addition to the need for baseline information with respect to oil and gas development, we felt it was important to verify whether a decline of muskoxen had taken place as suggested by Latour's (1985) estimate of a reduced population.

METHODS

The aerial survey was conducted in three stages: 1) an initial reconnaissance-type transect survey of the entire island was flown at 10% coverage, 2) areas of muskox or caribou concentrations were delineated, and 3) these high-density areas were then flown again at higher coverage (25-42%).

Two Cessna 185 STOL (short takeoff and landing) equipped aircraft on tundra tires were used for the survey. For the initial, reconnaissance-type survey, the island was divided into four parts (A, B, C, D), and transect lines (20 km apart) were drawn perpendicular to the major river drainages (Fig. 1). The survey was flown at an altitude of 180 m agl at an airspeed of about 160 kph (100 mph). Strip width was 1.0 km on each side of the aircraft for a total transect width of 2.0 km. The strip width was marked using wooden dowels taped to the wing struts according to the formula provided by Norton-Griffiths (1978). It was then checked against a known distance on the runway at Sachs Harbour during several passes of each aircraft at survey altitude (180 m).

In each aircraft, the pilot navigated and marked the locations of animals on 1:250,000 scale topographical maps. Two observers in the rear continuously searched for and counted muskoxen or caribou (non-calves) observed on transect. The number of calves was counted whenever possible. The information was transmitted on a Sigtronics 4-way intercom system and recorded on data sheets by the front-seat passenger who also assisted by spotting animals for the right rear observer.

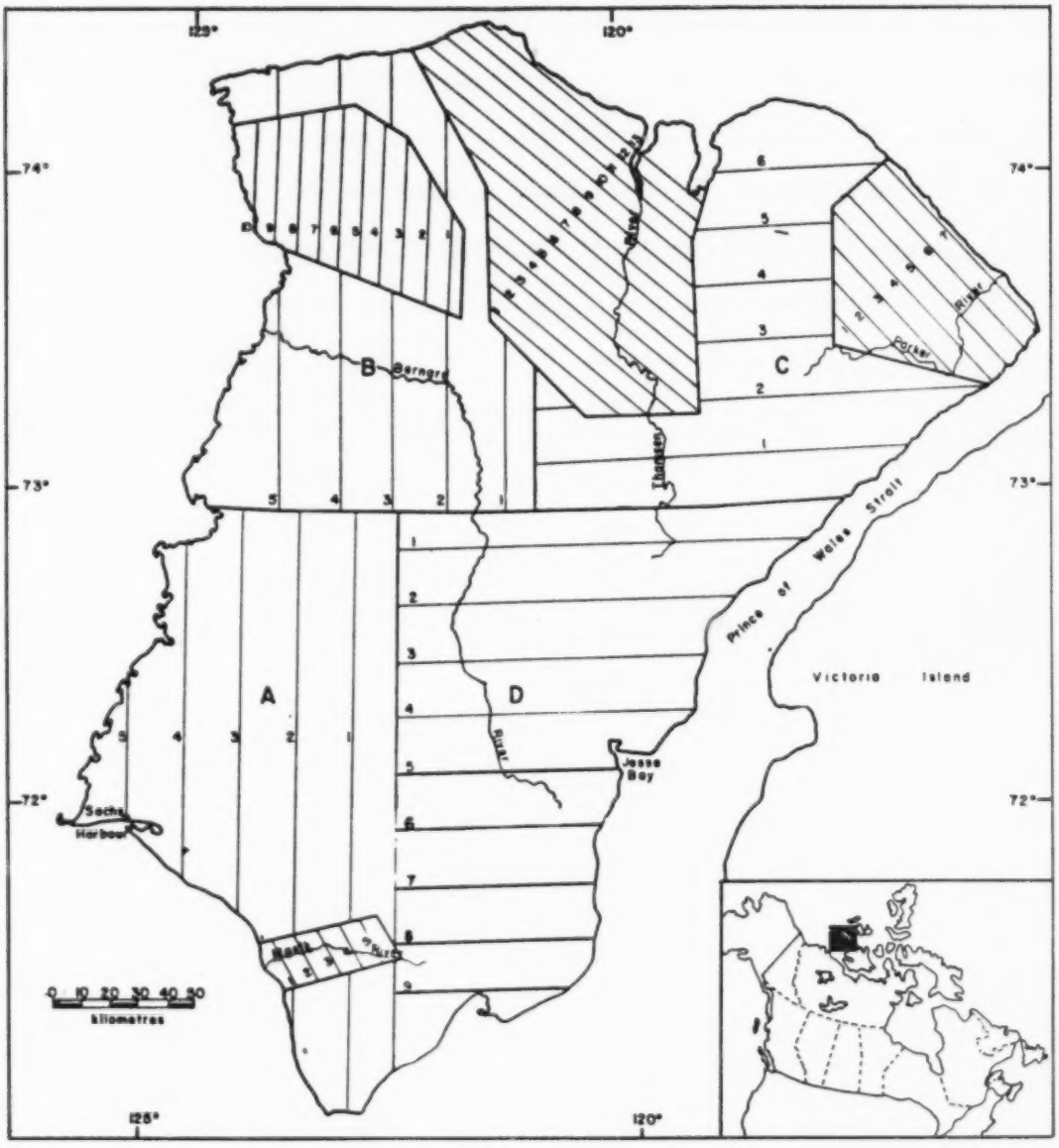

Figure 1. Transect lines and strata boundaries used during the muskox/caribou survey on Banks Island, July 1985.

Transect data were transcribed daily onto summary sheets. Descriptive statistics were calculated on an Apple IIc computer using a census data program based on Jolly (1969), method 2 for unequal sample sizes. Survey areas were calculated using a polar planimeter.

After the aerial survey, a camp was set up on the Thomsen River and one aircraft was used for low-level classification of muskox herds and for positioning of a ground crew who did preliminary range work. The classification flights were flown at slow speed (120-140 kph) and low altitude (50 m agl) in high-density muskox areas. At each pass, muskoxen were classified as calves or non-calves and total herd size was noted.

Transects to examine the percentage cover, frequency of occurrence and grazing intensity of plant species preferred by muskoxen were laid out at the confluence of the Muskox and Thomsen rivers in an area previously examined by Wilkinson et al. (1976). Methods and preliminary results of the range work are shown in Appendix A.

RESULTS

Field work was based in Sachs Harbour and conducted over the period 6-14 July, 1985. Low fog and poor visibility delayed the start of the aerial survey until 8 July. A total of 33 hours was flown between 8 and 9 July for the initial reconnaissance of the entire island (Fig. 1). From 10 to 12 July, the higher density areas were resurveyed (37 hrs), for a cumulative total of 70 hours of survey effort.

Muskox

Three areas of high muskox concentrations were identified from the initial survey: the Thomsen River, Parker River, and Masik River drainages (Fig. 1). Muskoxen were distributed more sparsely throughout the rest of the island, especially in areas of caribou concentration (NW Banks Island), and in the flat, wet, west-central part of the island drained by the Bernard River.

The total of 5867 muskoxen (non-calves) counted on-transect (Appendix B) extrapolates to an estimate of 25,700 ± 2050 (S.E.) muskoxen for Banks Island (Table 1). The high density strata covered about 14% of the island and accounted for half (12,800/25,700) of the estimated muskox population (Table 1). Densities ranged from 0.21 muskoxen/km^2 on South-Central Banks to 1.52 in the Thomsen River area (Fig. 2). Survey coverage was proportional to animal density and ranged from 8.8% on South-Central Banks to 41.5% in the Thomsen River stratum.

Table 1. Estimated numbers of muskoxen (non-calves), by stratum, on Banks Island, July 1985.

Stratum	Density (muskoxen/km^2)	Population estimate (± S.E.)	Coefficient of Variation	Coverage (%)
South-Central Banks	0.21	12,900 ± 1780	.14	8.8
Masik River	1.00	760 ± 185	.24	24.5
Parker River	0.87	2,800 ± 580	.21	25.5
Thomsen River	1.52	9,200 ± 820	.09	41.5
Total		25,700 ± 2050[b]	.08	12.5

[a] Proportion of stratum area sampled.

[b] DF = 25 (after Cochrane 1977:96)

Mean herd size (including calves) based on 663 herds observed on transect and excluding 262 lone bulls, was 9.5 ± 7.0 (S.D.) with a range of 2-40 (Table 2). The largest mean herd size was observed in the Thomsen River area (10.0), which had the highest density of muskoxen (Table 1), and was marginally larger than the low density area ($0.05>P>.01$). There were no significant differences between group sizes in the other strata. Lone bulls represented 4.0% (262/6569) of all muskoxen observed (Table 2). The highest proportion of lone bulls was observed in the Masik River stratum (10.6%) and the lowest in the Thomsen River area (3.0%).

Including lone bulls and herds, for which classification was attempted from the air, the proportion of calves to total classified was 11.8% (705/5975; Table 2). Between strata, calf percentages varied from 10.8% in the Thomsen River stratum to 14.8% in the Parker River area.

Low-altitude classification counts in the Thomsen River stratum, following the aerial survey, resulted in higher estimates of calf production. During the two days of flying (12 & 14 July), a total of 2129 muskoxen in 152 herds (mean herd size: 13.3 ± 6.9 S.D.) was classified (lone bulls excluded). Calves represented 16.8% of all muskoxen observed (357/2129). The results were similar between days.

During the aerial surveys, we observed a total of 20 recent muskox carcasses (6 bulls, 4 cows, 1 yearling, and 9 unknown), 14 of these were seen on transect. The carcasses had only been marginally scavenged, i.e., most or all of the hide was still on the animal. Of the 20

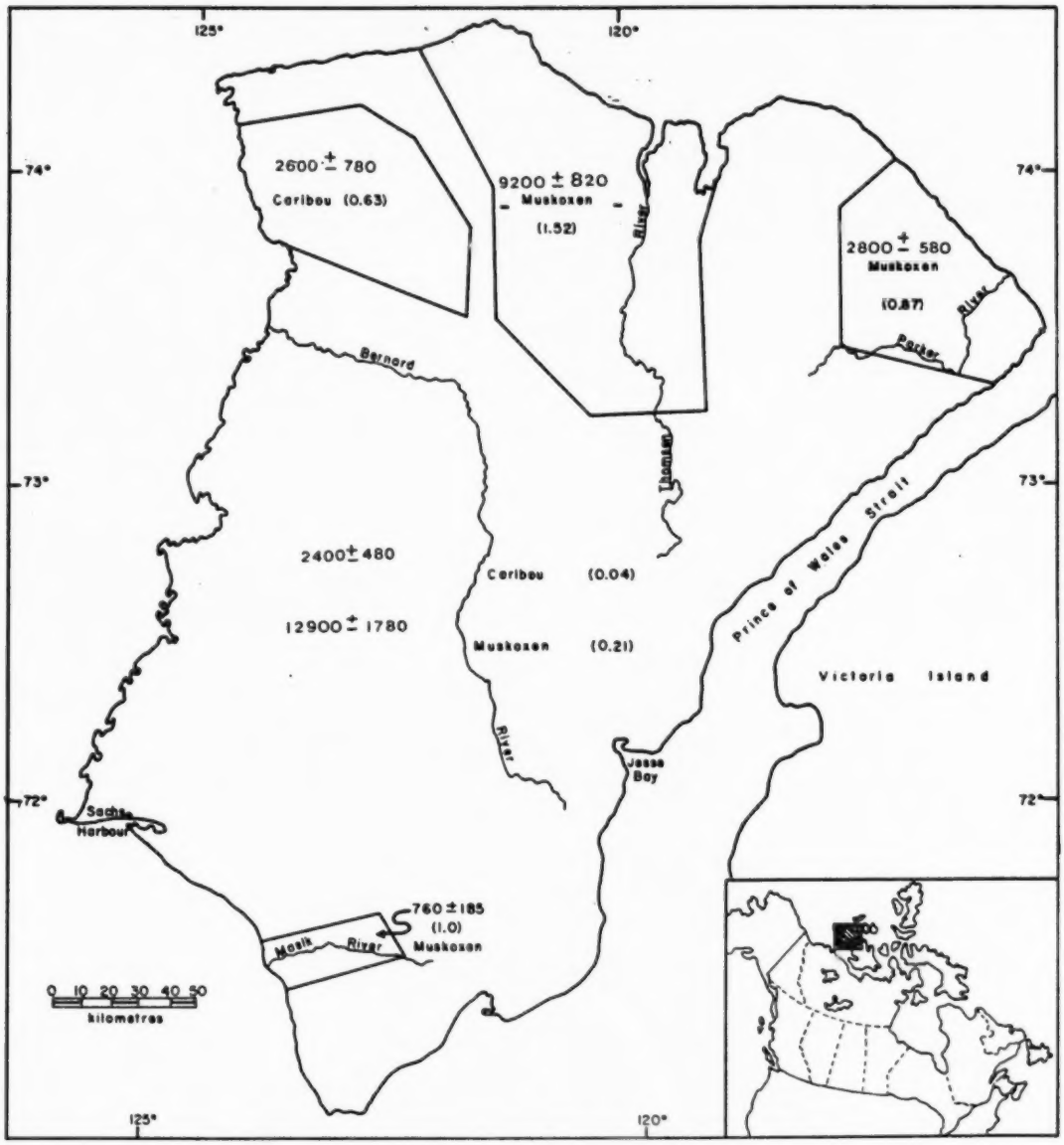

Figure 2. Population estimates and densities (per km^2), by stratum, for muskoxen and caribou on Banks Island, July 1985.

Table 2. Muskox herd characteristics (including calves), by stratum, on Banks Island, July 1985.

Stratum	Herd Size		Lone bull/ total (n)	Calf/ total (n)[a]
	Mean ± S.D. (n)	Range		
South-Central Banks	8.6 ± 6.6 (138)	2-34	5.2% (1298)	12.9% (1182)
Masik River	8.9 ± 8.1 (21)	2-30	10.6% (208)	13.4% (164)
Parker River	8.5 ± 6.6 (94)	2-40	5.4% (832)	14.8% (806)
Thomsen River	10.0 ± 7.2 (410)	2-43	3.0% (4231)	10.8% (3823)
Weighted means	9.5 ± 7.0 (663)	2-40	4.0% (6569)	11.8% (5975)

[a] Includes only muskoxen in herds, and lone bulls, that could be positively identified.

carcasses, 15 were found in the Thomsen River stratum (9 on transect). We were able to land and examine 3 carcasses: 2 (adult bull and cow)appeared to have been in poor physical condition, as evidenced by red gelatinous femur marrow and no visible back fat, and probably starved, while the third (a yearling) still had adequate fat reserves to discount starvation. No other signs were apparent to determine the cause of death. Both adult carcasses had been lightly scavenged by gulls (Larus spp.) as evidenced by excrement around the carcasses, missing eyes, and scavenger-made holes into the body cavity.

On 14 July, we conducted vegetation sampling in the Thomsen River area. The limited time available did not permit an examination of all vegetation types. A total of 70 0.8 m^2 plots were examined along two transects. Transect 1 (50 plots) passed through a wet sedge meadow, mostly Carex spp. and onto an upland area predominantly of Dryas integrifolia and willow (Salix pseudopolaris and Salix arctica). Transect 2 followed a snowbed community of abundant willow (mostly Salix alaxensis) and onto the upland Dryas/Salix vegetation. The highest grazing intensity observed was 21-40% in two plots. Fifty-four plots (77%) showed no signs of recent grazing, while 14 (20%) plots had 1-20% grazing. More details about the vegetation analysis are found in Appendix A.

Caribou

Caribou were sparsely distributed throughout most of Banks Island. An area of concentration was found in the northwestern part of the island

(Fig. 2). Few caribou were found in the high-density muskox areas. Generally, cow/calf groups and bulls-only groups were observed throughout the whole island, although very few calves were observed in the southwest part of the island. Observers also encountered some difficulty in classifying adults.

A total of 843 caribou (non-calves) was observed on transect, 626 in the high density area alone (Appendix D). An estimate of 5000 ± 910 (S.E.) caribou was calculated for the entire island (Table 3). The stratum on northwestern Banks, which covered approximately 6% of the island (Fig. 2) had over half (2,600/5,000) of the estimated caribou population (Table 3). Densities were 0.63 caribou/km^2 on NW Banks and 0.04 caribou/km^2 on the rest of the island.

The mean caribou group size (including calves) was 5.5 ± 4.5 (S.D.) in the low density areas and 8.3 ± 8.2 (S.D.) on NW Banks (Table 4) and differed significantly ($P<.05$, t-test).

Including individual caribou and all groups for which calf and total counts were determined, the proportion of calves to total was 15.3% (137/898), and ranged from 15.1% on NW Banks to 15.8% on the remainder of the island.

Table 3. Estimated numbers of non-calf caribou, by stratum, on Banks Island, July 1985

Stratum	Density (caribou/km^2)	Population estimate (± S.E.)	Coefficient of Variation	Coverage (%)[a]
South & East Banks	.04	2400 ± 480	.20	9.1
Northwest Banks	63	2600 ± 780	.30	24.4
Total		5000 ± 910[b]	.18	10.0

[a] Proportion of stratum area sampled.

[b] DF = 30 (after Cochrane 1977:96)

Table 4. Caribou group characteristics (including calves), by stratum, on Banks Island, July 1985.

Stratum	Group Size		Calf total (n)[a]
	Mean ± S.D. (n)	Range	
South & East Banks	5.5 ± 4.5 (44)	2 - 18	15.8% (240)
Northwest Banks	8.3 ± 8.2 (77)	2 - 39	15.1% (655)
Weighted mean	7.3 ± 7.2 (121)	2 - 39	15.3% (898)

a Includes only caribou groups or individuals that could be positively identified.

Wolves

During the aerial survey, a group of seven white, adult and subadult wolves and at least four pups were seen at a den located in a sandy hillside in the Parker River drainage. Herds of muskoxen as well as solitary bulls were in the area. The adult wolves looked thin and were shedding fur.

A pair of white, adult wolves was also observed from the air travelling along the Thomsen River. They appeared to be in good condition (large size, shiny fur).

DISCUSSION

Survey Conditions and Design

The survey was completed in five days during a short period of good weather. Survey conditions before and after this period were poor. Fog was encountered during the survey, especially in the highland areas on the northern part of the island. Transects which were interrupted by fog were completed later that day or the next day. Approximately 20% of all transects were partly affected. We believe that any movement within this short time would have been negligible. Snow cover was almost nil, with patches of snow only at higher elevations. The 1982 survey (Latour 1985) had a period of 10 days of clear skies and unlimited visibility in early July. Latour felt that caribou and muskoxen were readily visible at that time of year, especially as caribou were still in their white winter pelage. We had chosen the same timing for the 1985 survey based on Latour's (1985) recommendation.

The use of two aircraft proved effective as the weather was poor and one aircraft probably could not have finished surveying such a large area. By dividing the island into four parts for the reconnaissance survey, the transect lengths were shortened to minimize observer fatigue: the longest transect took 1.3 hr. Use of the STOL aircraft also made possible periodic landings for breaks during the survey.

Survey effort was proportional to density and the estimated effort (% coverage) was based on a study by one of the authors (Case, results unpubl.). Case mapped the distribution of animals located in the 1979-80 survey of Banks Island and then randomly marked transect lines on the map. The precision of the resulting estimates (i.e., the coefficient of variation) was plotted against effort (% coverage). From this graph it was possible to calculate a point for which increased effort did not yield a significant increase in precision. Norton-Griffiths (1978) also outlines this method of calculating survey effort. This levelling-off point occurred at approximately 35% coverage. However, for low-density areas, 10% coverage was felt to give adequate precision to the estimate. In this study, the coefficient of variation was for the muskox low density area. In addition, muskoxen and caribou concentrations were stratified and surveyed separately, which reduced the variance of the estimate.

Sightability of muskoxen was excellent and herds were usually spotted ahead of the plane. Counting error was not felt to be a problem due to the small herd sizes. Herd size was estimated for only 19 (3%) of the 663 herds of muskoxen observed (5% of individuals counted on transect). In the larger herds (> 15), calves were difficult to count, especially if the herd bunched up or stopped running. During the low-level classification counts, the calves were easier to count, as they were running or more spread out, especially if the aircraft approached from downwind. The classification counts suggest that estimates of calf numbers from the transect survey underestimate "true" calf production and survival.

Sightability of caribou was less satisfactory. In our survey, some caribou had already moulted to dark summer pelage (especially adult bulls) and were difficult to see on dark backgrounds particularly if they were not moving. Our estimate of the size of the caribou population is, therefore, low and should be considered a minimum.

Survey altitude and strip width were chosen as a compromise to account for the differential visibility of muskoxen and caribou. Muskoxen were easily observed from altitudes higher than 180 m and herds could be counted outside the transect strip. Caribou would have been easier to spot at a lower altitude or with a narrower strip width. However, costs were prohibitive for flying separate surveys for each species.

Population Characteristics

Muskox

The densities and population estimates from the 1985 survey are higher than those derived from the 1982 survey (Latour 1985) and more in agreement with the 1979-80 estimate by Vincent and Gunn (1981). They combined the results of surveying the southern half of Banks Island in 1979 with the results from the northern half in 1980 to arrive at their estimate of 19,000 ± 4100 (S.E.) (Table 5). Several problems with that survey, including the use of a Twin Otter as a survey aircraft and the lack of stratification, are outlined by Vincent and Gunn (1981).

Latour (1985) stratified the island into three strata after an initial reconnaissance. He used the same high density strata for both species and did not survey a large area of north-central and north-eastern Banks Is. (Figure 3). He excluded this area based on his reconnaissance which was not as extensive as ours and may have missed seeing animals. We calculated that this area was approximately 9600 km^2. Applying corresponding 1985 densities to this area (by strata) would increase Latour's estimate by about 8800 animals. Vincent (1980) also found high concentrations of muskoxen in the north-central region and the Parker River drainage in the northeast. Only one aircraft was used in the 1982 survey and possibly observer fatigue during long hours of flying accounted for missed animals or underestimation of herd size. Yet Latour (1985) did not report any difficulties in counting or recording animals.

Table 5. Summary of muskox survey information from Banks Island and N.W. Victoria Island

Year (Mon.)	Population estimate (C.V.)	Coverage (%)	Total[a] count	Lone bull/ total %(n)	Calf/ total %(n)	Herd Size Mean ± S.D.	Herd Size Range	Reference
Banks Island								
1985 (Jul)	25700(.08)	12.5	5867	4.0(6569)	11.8(5975)[b]	9.5±7.0 8.5±6.0[c]	2-40	This study
1982 (Jul.)	9393(.11)	15.5	2756	-	-	7.5±5.5[c]	2-40	Latour (1985)
1980 (March)[d]	14650(.10)	25.4	3743	-	-	14.9	1-70	Vincent (1980)
1979 (March)[d]	4678(.15)	26.1	1243	<1.0(1243)	13.2(1243)	14.3	1-75 (1979)	Vincent
NW Victoria Island								
1983 (Aug.)	6430(.08)	11.3	885	4.9(2172)	15.6(1896)	7.3±3.9	2-29	Jingfors (1985)
Queen Maud Gulf								
1982 (July)	8535(.16)	- [e]	3751	3.0(3890)	13.5(3751)	13.2±1.0	2-62	Gunn & Case (1984)

[a] On transect only.
[b] 16.8% (2129) calves during low-level classification counts.
[c] Excludes calves.
[d] Northern Banks Island in 1980, Southern Banks in 1979.
[e] Combined transect and block survey.

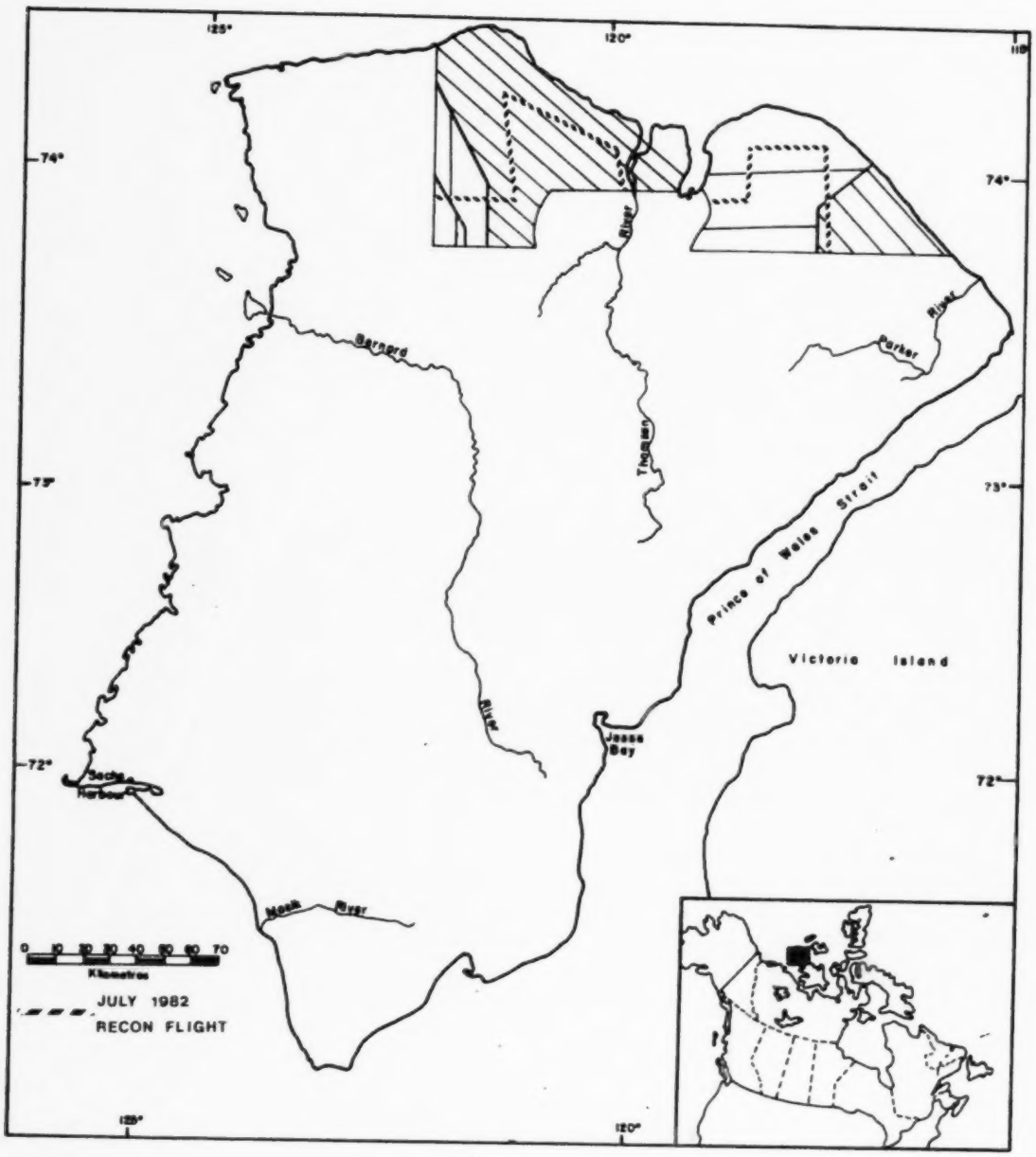

Figure 3. Transect lines used in the 1985 survey, in the area not surveyed in the 1982 survey.

The muskox population on Banks Island has been expanding for some time. Both high and low density areas had more animals in 1985 than previously. The three high density areas have historically been centres of muskox concentration (Urquhart 1973, Zoltai et al. 1980). Our results suggest that there has been further expansion of muskoxen into areas adjacent to these traditional areas of concentration, such as into the area northwest of the Thomsen River.

The highest density observed in this survey was 1.5 muskoxen/km^2 in the Thomsen River area. Latour (1985) reported a density of 0.93 muskoxen/km^2 in 1982, while Vincent and Gunn (1981) estimated a density of 0.93 muskoxen/km^2 in the Thomsen River area in 1980. The exact areas are different in the three surveys although they overlap.

High densities have been recorded from other arctic islands; 1.5 muskoxen/km^2 on Truelove Lowland, Devon Island (Hubert 1974) and from 1.0 to 2.6 muskoxen/km^2 on Bailey Point, Melville Island (Thomas et al. 1981). Thomas et al. (1981) suggested that the best muskox habitat could seemingly support 1-2 muskoxen/km^2 on a year-round basis, if winters were not too severe.

Calf production and survival of calves and yearlings reflect population condition. Increasing populations typically have a predominance of younger age groups, while stable or declining populations tend to have fewer young animals (Krebs 1972). The low-level classification flights resulted in a calf proportion of 16.8% in the Thomsen River area (calf proportions during the aerial survey ranged from 12.9-14.8% Table 2). Vincent (1979) found 13.2% calves in March 1979. Latour (1985) did not report calf percentages. Jingfors (1985)

found 15.6% calves in August during aerial surveys on N.W. Victoria Island, while Gunn and Case (1984) found 13.5% calves in July also during aerial surveys in the Queen Maud Gulf area (Table 5). Current calf production would appear to be good on Banks Island but not exceptional. Calf production averaged 19% for the introduced muskoxen on Nunivak Island over 20 years (Spencer and Lensink 1970) and 20% between 1983 and 1984 among muskoxen in Jameson Land, northeast Greenland (Thing et al. in press).

On 27-28 April 1985, ground classification counts of 191 muskoxen (12 herds) on Banks Island showed 12% yearlings (0.43 yearlings/cow 3 yrs. old and older), 13% calves (calving not completed) and 14% 2 yr-olds (K. Jingfors, field notes). Overwinter survival in the calf and yearling cohorts appeared good in 1984/1985. Jingfors and Klein (1982) state that the most reliable indicator of productivity among muskoxen is probably the number of calves per cow of reproductive age. Thus, to monitor productivity, ground-based classification counts are necessary to classify cows as well as calves, yearlings and 2-year olds.

Vincent and Gunn (1981) believe that the muskoxen on Banks Island should be regarded as having the demographic characteristics of an introduced population. "The pattern of an introduced population is of apparently rapid growth after establishment (or nadir of a decline) often followed by a rapid decline of the population if the population damages the new range" (Vincent and Gunn 1981). They calculated that the muskox population would have had to have grown at an annual rate of 20-25% (r=.21) from the 1972 estimate of 3800 (Urquhart 1973) to the 1980 estimate of 19,000 (Vincent and Gunn 1981). Growth rates of

14-23% have been observed in introduced herds in Alaska (Reynolds et al. 1985).

Latour's (1985) estimate of 9400±1050(S.E.) muskoxen implies an annual decline of approximately 20-40% per year (r=.33) from 1980 to 1982. The subsequent growth from 1982 to 1985 would have to have been from 30-50% per year (r=.34). Such a growth rate cannot be explained by natural increase alone.

The annual growth rate from 1980 to 1985 is 5.8% (r=.06) based on only the 1980 and 1985 estimates, and from 1973 to 1985 approximately 16% (r=.15). Spencer and Lensink (1970) observed a nearly constant rate of 16% annual growth over 23 years on Nunivak Island, Alaska, followed by a decline in calf production in subsequent years. If Urquhart's (1973) estimate was low (as he suggested it might be) or Vincent and Gunn's (1981) was high then the annual growth in the 1970s would have been less. Increased mortality, decreased calf production and later age of females producing their first calf would result in decreasing rates of increase. As evidence of high mortality was not observed based on the number of carcasses seen and calf production appeared to be good, we conclude that the muskox population is continuing to grow, although possibly at a lower rate.

Latour (1985) did not calculate the proportion of calves or lone bulls. Herd sizes (excluding calves) were slightly smaller in 1982, 7.5±5.5(S.D) vs 8.5±6.0(S.D) in 1985 (Table 5). Herd sizes ranged from 1 to 75 in March 1979 with a mean size of 14.3 (Vincent 1979). Muskoxen normally form larger herds during the winter months and smaller herds

in the summer (Tener 1965, Gray 1973). Similarly, lone bulls are more commonly seen in summer than in winter.

The 20 muskox carcasses that we found represent less than one percent of the total number of animals observed on transect. Few scavengers were observed and most carcasses appeared to be relatively intact. This suggests winter kill rather than predation kills, which are usually opened and subsequently scavenged. Animals that die in the winter (from poor condition) freeze solid, then the hide dries too hard for most avian scavengers or foxes to break through. The carcass stays intact for that subsequent summer (A. Gunn pers. comm.). Wilkinson and Shank (1976) suggested that rutting mortality accounted for the majority of carcasses they found. They examined only five of the seven carcasses they observed and admitted their evidence was circumstantial. The rut had not begun during the time of our survey.

Latour (1985) observed approximately 30 carcasses during the 1982 survey, the majority in the lower Muskox and Thomsen river drainages, some of which were probably up to 1.5 years old. He suggested that one of the seven carcasses he examined was in poor condition when it died (the others were too decayed to tell). Muskoxen examined during the spring commercial harvests on Southern Banks Island (1981, '82, '83, '84, '85) have all been in good to excellent physical condition (Tessaro et al. 1984, J. Rowell pers. comm.). The harvest takes place relatively close to Sachs Harbour, in the southern part of the island. We feel that it is necessary to conduct more ground work in the high muskox density areas, particularly the Thomsen River area, to document extent and causes of mortality, and physical condition of the animals.

Muskoxen were found along drainages and in areas of abundant Salix and Carex meadows. The use of these habitat types is consistent with other studies of summer range use (Tener 1965, Wilkinson et al. 1976).

Summer habitat does not yet appear to be limiting to muskoxen in the Thomsen River area. Wilkinson and Shank (1976) found muskoxen exploiting relatively small, scattered, highly productive stands of sedges and grasses in wet habitats. These areas and snow bed communities are not grazed in winter because of the deep snow cover. Wilkinson and Shank (1976) found that muskoxen grazed most of their foods with only light or moderate intensity and the authors thereby implied that food was not a limiting factor. More ground work is necessary to assess the impacts of grazing in high density areas.

We observed little overlap in the distribution of muskoxen and caribou. Wilkinson et al. (1976) concluded that muskoxen and caribou were not competing for food or space on their summer ranges in northern Banks Island. They found little overlap in the diets of the two species in summer and in winter. Other studies (Thomas and Edmonds 1984) also found no conclusive evidence for competition between caribou and muskoxen, even at high densities in Greenland and Alaska (Roby 1978, Lent and Knutsen 1971).

Caribou

The 1985 population estimate of 5000 ± 910 (S.E.) is lower than the previous estimate in 1982 of 7200 ± 1000 (Latour 1985). The two estimates are not significantly different statistically ($t=1.63$, $p=.10$), but may indicate a declining trend in numbers of caribou. Urquart (1973)

had estimated approximately 11,000 caribou (no confidence limits) in 1972, including over 2,000 calves. Vincent's (1980) estimate of 8,000-9,000 caribou was calculated by combining the 1979 and 1980 survey results. Latour (1985) believed that sightability of caribou was excellent, but in the 1985 survey we are less positive about our ability to detect caribou and we feel that we probably missed animals. Despite our problem of sightability, we believe that the population is stable or possibly declining.

The seasonal movements of caribou on Banks Island are more conspicuous than those of muskoxen. Urquhart (1973) found that caribou were more common in the southwest part of the island in winter and moved north or northeast to calving areas in spring. He found three major calving areas, the northwestern part of the island (north of Burnett Bay), around Jesse Bay on the east side of the island and a third area on the northeast coast. Latour (1985) also found a concentration of caribou, mainly cows and calves, immediately west of Jesse Bay. The densities observed in 1982 (Latour 1985) were similar to this survey in the high density caribou area, 0.58 caribou/km^2 versus 0.63 caribou/km^2. The density observed on the rest of the island was lower in the 1985 survey than 1982, 0.04 caribou/km^2 vs 0.08 caribou/km^2. Miller (1985) found a concentration of caribou on eastern Banks Island in May-June 1985. The composition was mostly breeding cows, newborn calves, juvenile females, and yearlings. Miller also found a concentration, predominantly of bulls, juveniles and yearlings, centred around Deans Dundas Bay on Victoria Island. He speculated that either the caribou observed on eastern Banks Island and western Victoria Island

represent an inter-island population; or that he failed to find the other components of the respective island populations. Miller was not able to find any direct evidence of inter-island movements between Banks and Victoria islands during the calving period, although he did not find winter pellets and tracks on Ramsey and Princess Royal islands.

Local people in Holman, on Victoria Island, reported to Kiliaan and Thomas (1983) that caribou cross in small groups between Banks and Victoria islands in fall and winter. Kiliaan and Thomas (1983) during an aerial survey found no evidence of movement across the strait in early June 1982 and 1983 (a windstorm likely filled in any tracks in 1982). Jingfors and Adjun (1984) observed caribou on Ramsey Island and found caribou signs on Princess Royal Islands suggesting that movement does occur between Banks and Victoria islands. Their ground survey in April was probably too early to detect springtime movements.

Peary caribou are believed to number 15-20,000 in total, over their entire range (Williams and Heard In prep.). The Banks Island population, therefore, represents approximately one third of this subspecies. The population estimate suggests that the annual harvest is approximately 10% of the population. Given this possible high rate of harvest and the importance of this population for the subspecies, more information is required to determine the status of Peary caribou on Banks Island.

Management

The muskox population on Banks Island is managed as one zone (B-1-1) with an annual quota of 2,000 animals (no sex restriction). This represents 8% of the current population estimate. The quota is for

subsistence use by the people of Sachs Harbour, guided sport-hunting of trophy bulls, and a commercial harvest. The commercial harvest for meat and by-products has occurred annually since 1981 (Tessaro et al. 1984). The largest number taken in one year was 224 in 1981 with only 46 slaughtered in the spring of 1985. Although the highest densities of muskoxen occur in the northern part of the island, the commercial harvest takes place in the south close to Sachs Harbour.

At current population levels, the commercial harvest could be increased, and efforts are now underway to receive Federal meat inspection approval for exporting the meat from the NWT and to develop a market for the by-products including hides and wool. Renewable Resources (GNWT) and the Western College of Veterinary Medicine (WCVM) from Saskatoon, Saskatchewan currently monitor the commercial harvest and collect biological information on the physical condition and reproductive status of harvested muskoxen. If the commercial harvest continues to be localized in the southwestern part of Banks Island, it may become increasingly difficult to find sufficient muskox numbers to support large-scale harvests. We need to know more about seasonal distribution and movements of muskoxen on the island, particularly the extent of north-south movements and whether areas of heavy harvesting are recolonized from the north.

The guided sport hunt takes approximately 15 bulls annually and generates income to the community. A muskox sports hunt costs approx. $5,000 and a combined muskox-polar bear hunt $20,000, with a large part of the money going to the community. The domestic subsistence harvest, we believe, is about 200 muskoxen per year. Mainly females and young

animals are taken for meat consumption, and recently, young calves have been harvested for hides (clothing).

Peary caribou is the preferred species for subsistence use. We believe that the annual harvest is currently about 500 animals. Most years, sufficient numbers of caribou winter in the southwestern parts of Banks Island and are readily accessible to hunters from Sachs Harbour. Most caribou are harvested in the fall (Oct./Nov.) when the animals are in prime physical condition; few are taken in the spring when the caribou have lost most of their fat. There is a commercial quota of 75 caribou tags for B-1-1. In addition, 20 caribou tags are set aside for sport hunting of trophy bulls.

RECOMMENDATIONS

1) The current muskox quota should remain in place to accommodate an expansion of the commercial harvest.

2) The seasonal distribution and movements of muskoxen should be monitored with particular reference to the localized commercial harvest on southwestern Banks Island. We propose to radio-collar 20 adult cows along the Big River drainage of southern Banks Island to document seasonal movements, herd dynamics and productivity.

3) Ground work in the Thomsen River area should be initiated in the summer of 1986 to provide information on the extent of muskox mortality and on the intensity of grazing in both summer and winter feeding areas. Range work is necessary to evaluate the effects of expanding muskox numbers on forage availability and uses.

4) The physical condition of muskoxen, including body weights, fat indices, and reproductive status, should continue to be monitored during the annual commercial harvest. A similar program to monitor the condition of hunter-killed caribou should be initiated in co-operation with the local H.T.A. Condition indices can be useful for predicting the potential for future problems, including severe winter conditions.

5) Spring composition counts of both muskoxen and caribou on southwest Banks Island should be done from snowmobiles in April-May every year to monitor calf survival and yearling recruitment which, in the absence of annual aerial surveys, will aid in assessing population trends.

6) Another stratified transect survey should be done in 1988 to document trends in the population size of muskoxen and caribou. The survey should be done in mid to late June and flown at a lower altitude with a narrower strip width to ensure better sightability of caribou.

7) The seasonal distribution and movements of Peary caribou should be monitored both on Banks Island and between Banks Island and Victoria Island. This information is necessary to delimit the range of the population and to determine the extent of inter-island movements. Radio tracking, by aircraft or satellite, would be the most effective technique to monitor these movements.

8) In co-operation with the local H.T.A., the Inuvialuit Game Council (IGC) and Renewable Resources should initiate a harvest study to record the annual harvest of Peary caribou and muskoxen. This information is required to prepare species management plans.

ACKNOWLEDGEMENTS

We would like to thank Les Kutny (Renewable Resources, Inuvik) who ably participated in the survey and assisted in the preparation of the report. Peter Esau and Geddes Wolkie of Sachs Harbour were excellent observers during the survey. Jeff Mahoney (Aklak Air) and Bill Sutherland (Antler Aviation) enthusiastically piloted the aircraft and kept us on transect. Anne Gunn and Doug Heard provided helpful comments and Joyce Mitchell typed the report faster than we could write.

PERSONAL COMMUNICATIONS

Gunn, A. Regional Biologist, Renewable Resources, GNWT, Cambridge Bay, NWT.

Rowell, J. Western College of Veterinary Medicine (WCVM), Univ. Saskatchewan, Saskatoon, Sask.

LITERATURE CITED

Cochrane, W.G. 1977. Sampling techniques. John Wiley and Sons, Toronto. 428 pp.

Gray, D.R. 1973. Social organization and behaviour of muskoxen on Bathurst Island, NWT. Ph.D. Thesis, Univ. Alberta, Edmonton. 212 pp.

Gunn, A. and R. Case. 1984. Numbers and distribution of muskoxen in the Queen Maud Gulf Area, July, 1982. NWT Wildl. Serv. File Rep. No. 39. 56 pp.

Hone, E. 1934. The present status of the muskox. Spec. Publ. Amer. Comm. Intern. Wildl. Protection No. 5. 87 pp.

Hubert, B. 1974. Estimated productivity of muskox (Ovibos moschatus) on northeastern Devon Island, NWT. MSc. Thesis, Univ. Manitoba, Winnipeg. 118 pp.

Jingfors, K. 1985. Abundance and distribution of muskoxen on northwestern Victoria Island. NWT Wildl. Serv. File Rep. No. 47. 22 pp.

Jingfors, K. and C. Adjun. 1984. Wildlife Survey along Prince of Wales Strait, April 1984. NWT Wildl. Serv. Manuscript Report.

Jingfors, K. and D.R. Klein, 1982. Productivity in recently established muskox populations in Alaska. J. Wildl. Manage. 46(4):1092-1096.

Jolly, G.M. 1969. Sampling methods for aerial censuses of wildlife populations. E. Afr. Agric. For. J. 34:46-49.

Kiliaan, H.P.L. and D.C. Thomas, 1983. Reconnaissance surveys of Prince of Wales Strait and southern Melville Island, in June 1982 and 1983. Unpubl. Can. Wildl. Serv. unpubl. rep. 20 pp.

Krebs, C.J. 1972. Ecology. The experimental analysis of distribution and abundance. Harper and Row, New York. 694 pp.

Latour, P. 1985. Population estimates for Peary caribou and muskoxen on Banks Island in 1982. NWT Wildl. Serv. File Rep. No. 49. 21 pp.

Lent, P.C. and D. Knutsen. 1971. Muskox and snow cover on Nunivak Island. Pages 50-62 in A.D. Haugen, ed. Symposium on snow and ice in relation to wildlife and recreation. Iowa State Univ. Press. Ames.

Miller, F.L. 1985. Investigation of possible inter-island movements of Peary Caribou between Banks and Victoria Islands, Northwest Territories. Can. Wild. Serv. unpubl. rep. 3 pp.

Norton-Griffiths, M. 1978. Counting animals. Serenget. Ecological Monitoring Programme Handbook No. 1. Afr. Wildl. Leadership Found. Nairobi, Kenya. 110 pp.

Reynolds, P.E., L.D. Martin, C.J. Weiler, J.M. Noll and J.M. Morton, 1985. Population and herd dynamics, distribution, movements, and habitat use of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982-1984. Pages 43-85 in G.W. Garner and P.E. Reynolds, eds. 1984 update report baseline study of the fish, wildlife and their habitats. U.S.F.W.S. Anchorage, Alaska. 777 pp.

Roby, D.D. 1978. The status of muskoxen (Ovibos moschatus) in West Greenland. Alaska Cooperative Wildlife Research Unit Progress Report 30:80-82.

Spencer, D.L. and C.J. Lensink. 1970. The muskox of Nunivak Island, Alaska. J. Wildl. Manage, 34(1):1-15.

Tener, J.S. 1965. Muskoxen in Canada. Can. Wildl. Serv. Monogr. Ser. No. 2. 166 pp.

Tessaro, S., J.E. Rowell, R. Cawthorn, and P. Latour. 1984. Banks Island muskox harvest 1982. Biol. Pap. Univ. Alaska. Spec. Rep. No. 4:177-180.

Thing, H., D.R. Klein, K. Jingfors, and S. Holt. In press. Assessment of the ecology of muskoxen in Jameson Land, northeast Greenland. Submitted to Holarctic Ecology. 40 pp.

Thomas, D.C. and J.E. Edmonds. 1984. Competition between caribou and muskoxen, Melville Island, NWT, Canada. Biol. Pap. Univ. Alaska Spec. Rep. No. 4:93-100.

Thomas, D.C., F.L. Miller, R.H. Russell and G.R. Parker. 1981. The Bailey Point region and other muskox refugia in the Canadian Arctic: a short review. Arctic 34(1): 34-36.

Urquhart, D.R. 1973. Oil exploration and Banks Island Wildlife. NWT Wildl. Serv. unpubl. rep. 105 pp.

Vincent, D. 1979. South Banks Island muskox/caribou survey. NWT Wildl. Serv. unpubl. rep. 25 pp.

Vincent, D. 1980. North Banks Island muskox/caribou survey. NWT Wildl. Serv. unpubl. rep. 30 pp.

Vincent, D. and A. Gunn. 1981. Population increase of muskoxen on Banks Island and implications for competition with Peary Caribou. Arctic. 34:175-179.

Wilkinson, P.F. and C.C. Shank. 1976. Rutting-fight mortality among muskoxen on Banks Island, NWT. Canada. Anim. Behav., 24:756-758.

Wilkinson, P.F., C.C. Shank, and D.F. Penner. 1976. Muskox-caribou summer range relations on Banks Island, NWT. J. Wildl. Manage. 40(1):151-162.

Will, R.T. 1984. Muskox procurement and use on Banks Island by nineteenth century Copper Inuit. Biol. Pap. Univ. Alaska. Spec. Rep. No. 4:153-161.

Williams, M. and D. Heard. In prep. World status of wild Rangifer populations. Rangifer.

Zoltai, S.C., D.J. Karasiuk, and G.W. Scotter. 1980. A natural resource survey of the Thomsen River area, Banks Island, Northwest Territories. Prepared for Parks Canada, Environment Canada. 153 pp.

APPENDIX A. Vegetation analysis conducted in the Thomsen River area, Banks Island, July 1985.

On 14 July, vegetation was examined in the Thomsen River area to monitor the intensity of grazing by muskoxen. The limited time available did not permit sampling of all vegetation types. The results of the survey should be considered preliminary to more intensive work.

METHODS

The aircraft landed near the junction of the Thomsen and Muskox rivers in the area where Wilkinson et. al (1976) reported on the vegetation in 1973. Two transects were followed out from the Muskox River. At 100-m intervals, a section of the transect was examined on 10 sample plots, spaced 10 m apart. Each sample plot was formed by using two folding rulers to make a square of 0.8 m^2. On the south side of the Muskox River, five segments of 10 plots each (total of 50) were examined. On the north side of the river (transect 2), two segments of 10 plots each were sampled (total of 20). The same methods as Wilkinson et al. (1976) were used. Within each sample plot, percentage vegetation cover (excluding lichens, moss and dead vegetation); composition, as a percentage of the vegetation cover; grazing intensity (on a scale of 0 = none, 1 = 1 - 20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, 5 = 81-100%), and the species grazed; and any other additonal comments, e.g., presence of dung, were recorded.

RESULTS

The vegetation on northern Banks Island is dominated by polar semi-desert and desert community types, with local areas of Arctic tundra (Zoltai et. al 1980). Transect 1 passed through wet sedge meadows and onto uplands which were predominantly tussocks of *Dryas integrifolia*, *Salix pseudopolaris* and *Salix Arctica*. Transect 2 passed through a "snow bed" area of abundant *Salix* spp. (mostly *S. alaxensis*) and onto the upland *Dryas*/*Salix* vegetation type.

The highest grazing intensity observed was 2 (21-40%) observed in 2 plots. No recent signs of grazing were found in 54 (77%) of the plots examined (Table 6). Old browsing of willow stems was found in 15 plots. Lemmings (*Dicrostonyx torquatus*) and Arctic hares (*Lepus arcticus*) may have contributed to this winter browsing. Lemming "nests" were observed in several areas especially where willow mat predominated.

Table 6 - Grazing intensity by muskoxen in the Thomsen River Valley, July 1985.

Transect No.	Grazing Intensity (% of plants grazed)					
	0 (0)	1 (1-20)	2 (21-40)	3 (31-60)	4 (61-80)	5 (81-100)
Transect 1 (n=50)	37	11 (7)[a]	2			
Transect 2 (n=20)	17	3	(5)[a]			
All plots (n=70)	54(77%)	14(20%) (10-14)[a]	2(3%) (5-7)[a]			

[a] Figures in parentheses refer to old signs of browsing - likely from last winter.

APPENDIX B. Numbers of muskoxen observed on transect on Banks Island, July 1985.

Transect Number	Transect area (km^2)	Left		Right	
		Non-calves	Calves	Non-calves	Calves
South-Central Banks (8.8% coverage)					
1	390	24	3	78	10
2	326	78	14	54	5
3	290	60	5	19	1
4	240	20	1	-	-
5	95	9	-	-	-
6	127	-	-	8	1
7	300	98	4	50	2
8	326	34	3	54	7
9	320	22	-	29	2
10	312	21	-	46	11
11	264	76	15	87	13
12	227	17	3	38	6
13	116	20	2	-	-
14	114	-	-	10	3
15	52	2	-	-	-
16	84	6	1	11	2
17	296	1	-	5	-
18	246	2	-	-	-
19	220	27	5	24	4
20	216	8	2	29	6
21	160	-	-	9	2
22	150	2	-	1	-
23	146	8	1	-	-
24	146	6	3	4	-
25	126	17	7	17	5
Totals	5289	558	69	573	80

APPENDIX B. (cont'd)

Transect Number	Transect area (km^2)	Left		Right	
		Non-calves	Calves	Non-calves	Calves
Masik River (24.5% coverage)					
1	38	15	2	37	-
2	38	21	-	37	6
3	38	30	6	26	6
4	36	8	2	3	-
5	36	6	-	3	-
Totals	186	80	10	106	12
Parker River (25.5% coverage)					
1	31	36	7	1	-
2	75	21	3	26	5
3	119	51	10	93	12
4	146	100	17	94	16
5	156	68	8	28	5
6	140	58	8	120	25
7	164	12	-	16	3
Totals	831	346	53	378	66
Thomsen River (41.5% coverage)					
1	130	39	5	21	1
2	155	66	5	85	15
3	175	132	20	83	6
4	185	172	13	137	20
5	185	167	13	178	13
6	182	277	29	13	7
7	180	132	21	230	25
8	208	116	30	164	23

APPENDIX B. (cont'd)

Transect Number	Transect area (km^2)	Left		Right	
		Non-calves	Calves	Non-calves	Calves
Thomson River					
9	222	202	27	174	18
10	242	199	20	220	18
11	230	219	19	221	28
12	221	108	7	116	14
13	209	112	13	113	12
Totals	2524	1941	222	1885	200
Survey Totals	8830	2925	354	2942	358

APPENDIX C. Number of caribou observed on transect on Banks Island, July 1985.

Transect Number	Transect area (km^2)	Left		Right	
		Non-calves	Calves	Non-calves	Calves
South and East Banks (9.1% coverage)					
1	426	5	1	15	4
2	365	-	-	-	-
3	290	-	-	-	-
4	240	1	-	2	-
5	106	-	-	-	-
6	346	-	-	2	-
7	260	2	-	-	-
8	206	3	2	-	-
9	198	-	-	2	-
10	215	2	-	5	-
11	264	18	4	-	-
12	315	8	2	9	3
13	360	17	4	16	4
14	340	30	-	5	-
15	246	-	-	1	-
16	179	-	-	-	-
17	296	6	-	-	-
18	246	-	-	4	2
19	220	11	1	2	-
20	216	-	-	-	-
21	160	4	-	27	11
22	150	8	2	1	-
23	146	9	6	-	-
24	146	-	-	1	1
25	126	1	-	-	-
Totals	6062	125	22	92	25

APPENDIX C. (cont'd)

Transect Number	Transect area (km^2)	Left		Right	
		Non-calves	Calves	Non-calves	Calves
Northwest Banks (24.4% coverage)					
1	74	11	-	4	1
2	88	3	-	14	-
3	104	11	-	14	4
4	116	20	2	54	15
5	120	19	6	58	12
6	110	181	16	82	17
7	116	47	7	36	7
8	106	7	-	13	-
9	90	17	2	9	1
10	64	5	-	21	3
Totals	988	321	33	305	60
Survey Totals	7050	446	55	397	85